Claims

I claim:

1. A method of manufacturing an integrated circuit device that comprises an insulation layer, the method comprising:

exposing at least a portion of an insulation layer that comprises oxygen to a metal precursor that is reactive with oxygen so as to form a first metal oxide layer on the at least a portion of the insulation layer.

2. The method of Claim 1, wherein exposing the at least a portion of the insulation layer that comprises oxygen to the metal precursor comprises:

pulsing the metal precursor over the integrated circuit device; and

exposing the integrated circuit device to an inert gas.

3. The method of Claim 2, wherein pulsing the metal precursor is performed for a duration of about 0.1 to 2 seconds and at a flow rate of about 50 to 300 sccm.

4. The method of Claim 2, wherein exposing the integrated circuit device to an inert gas is performed for a duration of about 0.1 to 10 seconds and at a flow rate of about 50 to 300 sccm.

5. The method of Claim 2, wherein pulsing the metal precursor comprises:

pulsing the metal precursor and a carrier gas over the integrated circuit device.

6. The method of Claim 5, wherein the carrier gas is argon.

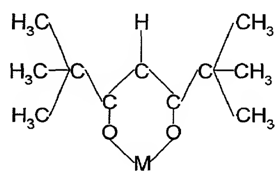
7. The method of Claim 2, further comprising:

thermally treating the integrated circuit device in an oxygen atmosphere using one of a rapid thermal processing apparatus and a furnace type thermal processing apparatus.

8. The method of Claim 7, wherein thermally treating the integrated circuit device comprises:

thermally treating the integrated circuit device in the oxygen atmosphere using a rapid thermal processing apparatus at a temperature of about 400 to 600°C for a duration of about 10 seconds to 10 minutes.

9. The method of Claim 1, wherein the metal precursor comprises a gas selected from the group of gases consisting of TriMethyl Aluminum (TMA), DiMethylAluminum Hydride (DMAH), DiMethylEthylAmine Alane (DMEAA), TriIsoButylAluminum (TIBA), TriEthyl Aluminum (TEA), $TaCl_5$, $Ta(OC_2H_5)_4$,$TiCl_4$, $Ti(OC_2H_5)_4$, $ZrCl_4$, $HfCl_4$, $Nb(OC_2H_5)_5$, $Mg(thd)_2$, $Ce(thd)_3$, and $Y(thd)_3$, wherein thd is given by the following structural formula:



10. The method of Claim 1, wherein exposing the at least a portion of the insulation layer that comprises oxygen to the metal precursor is performed at a temperature of about 100 to 400°C and at a pressure of about 0.1 to 1 torr.

11. The method of Claim 1, wherein the insulation layer comprises a capacitor dielectric layer.

12. The method of Claim 1, wherein the insulation layer comprises a material selected from the group of materials consisting of: TiO_2, SiO_2, Ta_2O_5, Al_2O_3 , $BaTiO_3$, $SrTiO_3$, (Ba, Sr)TiO_3, $Bi_4Ti_3O_{12}$, $PbTiO_3$, PZT((Pb, La)(Zr, Ti)O_3), and ($SrBi_2Ta_2O_9$)(SBT).

13. The method of Claim 1, further comprising:

encapsulating the first metal oxide layer and the insulation layer in a second metal oxide layer.

14. An integrated circuit device, comprising:

a capacitor that comprises a lower electrode layer, a dielectric layer on the lower electrode layer, and an upper electrode layer on the dielectric layer;

a first metal oxide layer that is disposed on an exposed portion of the dielectric layer and has a first density associated therewith; and

a second metal oxide layer that encapsulates the capacitor and the first metal oxide layer and has a second density associated therewith that is greater than the first density.

15. The integrated circuit device of Claim 14, wherein the first and second metal oxide layers each comprise an element selected from the group of elements consisting of: Al, Ta, Ti, Zr, Mg, Ce, Y, Nb, Hf, Sr, and Ca.

16. The integrated circuit device of Claim 14, wherein the dielectric layer comprises a material selected from the group of materials consisting of: TiO_2, SiO_2, Ta_2O_5, Al_2O_3 , $BaTiO_3$, $SrTiO_3$, (Ba, Sr)TiO_3, $Bi_4Ti_3O_{12}$, $PbTiO_3$, PZT((Pb, La)(Zr, Ti)O_3), and ($SrBi_2Ta_2O_9$)(SBT).

17. The integrated circuit device of Claim 14, wherein the first metal oxide layer is disposed on a sidewall of the dielectric layer and a portion of a surface of the dielectric layer that is adjacent to the upper electrode.

18. A method of manufacturing an integrated circuit device, comprising:

forming an insulation layer that comprises oxygen on a substrate; and

forming a first metal oxide layer on at least a portion of the insulation layer by exposing the at least a portion of the insulation layer to a first metal precursor that is reactive with the oxygen in the insulation layer.

19. The method of Claim 18, further comprising:

forming a lower electrode on the substrate; and

forming an upper electrode on the insulation layer;

wherein forming the insulation layer that comprises oxygen on the substrate comprises:

forming the insulation layer that comprises oxygen on the lower electrode.

20. The method of Claim 19, further comprising:

forming a second metal oxide layer on the substrate that encapsulates the lower electrode, the insulation layer, the first metal oxide layer, and the upper electrode.

21. The method of Claim 20, wherein forming the first metal oxide layer comprises:

pulsing the first metal precursor over the integrated circuit device; and

exposing the integrated circuit device to an inert gas.

22. The method of Claim 21, wherein forming the second metal oxide layer comprises:

pulsing a second metal precursor over the integrated circuit device;

exposing the integrated circuit device to an inert gas; then

pulsing oxygen gas over the integrated circuit device; then

exposing the integrated circuit device to an inert gas.

23. The method of Claim 18, further comprising:

thermally treating the integrated circuit device in an oxygen atmosphere using one of a rapid thermal processing apparatus and a furnace type thermal processing apparatus.

24. The method of Claim 18, further comprising:

forming a conductive region on the substrate, the insulation layer being disposed on the conductive region and the substrate;

forming an opening in the insulation layer so as to expose at least a portion of the conductive region; and

forming the first metal oxide layer on the at least a portion of the insulation layer while maintaining the exposed portion of the conductive region substantially devoid of the first metal oxide layer by exposing the at least a portion of the insulation layer and the exposed portion of the conductive region to the first metal precursor that is reactive with the oxygen in the insulation layer.